

UNITED STATES PATENT OFFICE

2,468,237

MODULATION APPARATUS

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Application May 24, 1947, Serial No. 750,346

7 Claims. (Cl. 332-44)

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This invention relates to modulating apparatus, and more particularly to apparatus for modulating electromagnetic energy in the microwave region of the spectrum.

The invention contemplates the provision of means, for example, a wave-guide section, having a perpendicularly extending branch arm receptive of a carrier wave, for deriving from said carrier wave two constituent waves of opposite phase. Said constituent waves are applied to means, for example, a pair of non-linear impedances which terminate the opposite ends of said wave-guide section, which are also receptive, in push-pull fashion, of a modulation wave, whereby two additional constituent waves of opposite phase are derived and combine, respectively, with said first-named constituent waves to produce sideband waves. Said sideband waves, together with portions of said first-named constituent waves reflected from said non-linear impedances, are fed to means, for example, a second branch arm extending perpendicularly from said wave-guide section, perpendicularly to said first-named branch arm, whereby said sideband waves are combined and transmitted to a load, and said reflected portions of said first-named constituent waves are combined so as to suppress the same in the direction of said load.

In the accompanying specification there shall be described, and in the annexed drawing shown, an illustrative embodiment of the modulating apparatus of the present invention. It is, however, to be clearly understood that the present invention is not to be limited to the details herein shown and described for purposes of illustration only, inasmuch as changes therein may be made without the exercise of invention, and within the true spirit and scope of the claims hereto appended.

In said drawing, the single figure is a schematic diagram of a modulating device assembled in accordance with the principles of the present invention.

Referring now more in detail to the aforesaid illustrative embodiment of the present invention, with particular reference to the drawing illustrating the same, the numeral 10 generally designates what may be termed a double T-shaped wave-guide assembly. Such an assembly includes a cross-arm 11 from the center of which, or from what will hereinafter be called a common junction 12, extend two branch arms 13 and 14, said cross-arm being common to both T's, and said branch arms being perpendicular to said cross-arm, and to each other. As herein shown,

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for purposes of simplicity of illustration, the branch arm 14 recedes from the observer for a short distance from the common junction 12, then bends downwardly, and is then twisted through an angle of 90°.

The opposite ends of the cross-arm terminate, respectively, in non-linear impedances, for example, rectifying crystals 15 and 16, said crystals being similarly disposed with respect to each other, and having one end of each directly connected, as at 17 and 18, to said cross-arm which, in turn, is grounded, as shown. Conductors 19 and 20 are connected to the remaining terminals of said crystals and pass through insulators 21 and 22 mounted in said cross-arm, said conductors being connected to the opposite ends of a center-tapped and grounded secondary winding 23 of an input transformer 24, thereby providing a push-pull input to the crystals. The transformer 24 includes a primary winding 25.

For an understanding of the operation of the device, assume that a carrier wave ω_c traveling down the branch arm 13 toward the common junction 12 with its electric vector pointing, arbitrarily, to the right. As this wave reaches the junction 12, it splits into two constituent waves, one, having its electric vector pointing downwardly, traveling along the cross-arm wave guide section 11 toward the crystal 15, and the other, having its electric vector pointing upwardly, traveling along said wave-guide section 11 toward the crystal 16.

Now, further assume that a modulation wave ω_m is applied to the transformer 24, and that the two constituent waves derived therefrom, by reason of the push-pull connection thereof across the crystals 15 and 16, have their electric vectors pointing in opposite directions, arbitrarily, upwardly at the crystal 15 and downwardly at the crystal 16.

Thus, there arrives at the crystal 15, two oppositely-phased constituent waves, and there arrives at the crystal 16, two, also, oppositely-phased constituent waves. As a result, the phases of the side band $\omega_c \pm \omega_m$ produced, respectively, at the crystals 15 and 16 may be considered negative inasmuch as the component waves of each are of opposite phase.

The similarly-phased sideband waves thus produced, together with the out-of-phase portions of the carrier constituent waves reflected from the crystals 15 and 16, travel along the wave-guide section 11 toward the common junction 12. At said junction, the sideband waves combine and are propagated along the branch arm 14. The

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crystal-reflected carrier waves combine and are propagated back along the branch arm 13 from whence the initial carrier wave came, but since these crystal-reflected carrier waves are of opposite phase, they are suppressed in the direction of the branch arm 14. Thus sideband and carrier waves are effectively separated.

While the branch arm 13 has, in the foregoing description, been considered as the input for the carrier wave, it is desired to point out that the branch arm 14 may be used as the input for the carrier, in which case the branch arm 13 becomes the output for the sidebands.

This completes the description of the afore-said illustrative embodiment of the present invention.

What is claimed is:

1. Modulating apparatus comprising: means, receptive of a carrier wave, for deriving therefrom two constituent waves; means, receptive of a modulation wave and receptive of said constituent waves, for deriving from the former two additional constituent waves of opposite phase, and combining the same, respectively, with said first-named constituent waves whereby sideband waves are produced; and means, receptive of said sideband waves and receptive of portions of said first-named constituent waves reflected from said last-named means, for combining said sideband waves and transmitting the same to a load, and combining said reflected portions of said first-named constituent waves and suppressing the same in the direction of said load.

2. Modulating apparatus comprising: a wave-guide section, having a perpendicularly extending branch arm receptive of a carrier wave, for deriving from said carrier wave two constituent waves; means, terminating the opposite ends of said wave-guide section, receptive of a modulation wave and receptive of said constituent waves, for deriving from the former two additional constituent waves of opposite phase, and combining the same, respectively, with said first-named constituent waves whereby sideband waves are produced; and a second branch arm extending perpendicularly from said wave-guide section, perpendicularly to said first-named branch arm, receptive of said sideband waves and receptive of portions of said first-named constituent waves reflected from said last-named means, for combining said sideband waves and transmitting the same to a load, and combining said reflected portions of said first-named constituent waves and suppressing the same in the direction of said load.

3. Modulating apparatus comprising: a wave-guide section, having a perpendicularly extending branch arm receptive of a carrier wave, for deriving from said carrier wave two constituent waves; a pair of non-linear impedances terminating the opposite ends of said wave-guide section, receptive of a modulation wave and receptive of said constituent waves, for deriving from the former two additional constituent waves of opposite phase, and combining the same, respectively, with said first-named constituent waves whereby sideband waves are produced; and a second branch arm extending perpendicularly from said wave-guide section, perpendicularly to said first-named branch arm, receptive of said sideband waves and receptive of portions of said first-named constituent waves reflected from said non-linear impedances, for combining said sideband waves and transmitting the same to a load, and combining said reflected portions of said first-named con-

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stituent waves and suppressing the same in the direction of said load.

4. Modulating apparatus comprising: a wave-guide section, having a perpendicularly extending branch arm receptive of a carrier wave, for deriving from said carrier wave two constituent waves; a pair of non-linear impedances terminating the opposite ends of said wave-guide section, receptive, in push-pull, of a modulation wave and receptive of said constituent waves, for deriving from the former two additional constituent waves of opposite phase, and combining the same, respectively, with said first-named constituent waves whereby sideband waves are produced; and a second branch arm extending perpendicularly from said wave-guide section, perpendicularly to said first-named branch arm, receptive of said sideband waves and receptive of portions of said first-named constituent waves reflected from said non-linear impedances, for combining said sideband waves and transmitting the same to a load, and combining said reflected portions of said first-named constituent waves and suppressing the same in the direction of said load.

5. A balanced modulator comprising: a wave-guide section having a non-linear impedance at each of its opposite ends; a carrier-receiving branch arm extending perpendicularly from said wave-guide section; a source of modulation; an impedance, receptive of said modulation, connected in push-pull relationship to said non-linear impedances; and a sideband-receiving branch arm extending perpendicularly from said wave-guide section perpendicularly to said carrier-receiving branch arm.

6. A balanced modulator comprising: a wave-guide section having a crystal detector at each of its opposite ends; a carrier-receiving branch arm extending perpendicularly from said wave-guide section; a source of modulation; an impedance, receptive of said modulation, connected in push-pull relationship to said crystal detectors; and a sideband-receiving branch arm extending perpendicularly from said wave-guide section, perpendicularly to said carrier-receiving branch arm.

7. A balanced modulator comprising: a wave-guide section having a non-linear impedance at each of its opposite ends; a carrier-receiving branch arm extending perpendicularly from said wave-guide section; a modulation-receiving impedance connected in push-pull relationship to said non-linear impedances; a sideband-receiving branch arm extending perpendicularly from said wave-guide section, perpendicularly to said carrier-receiving branch arm; and a load connected across said sideband-receiving branch arm.

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